WADGPS *CONTINUED FROM PAGE 6*

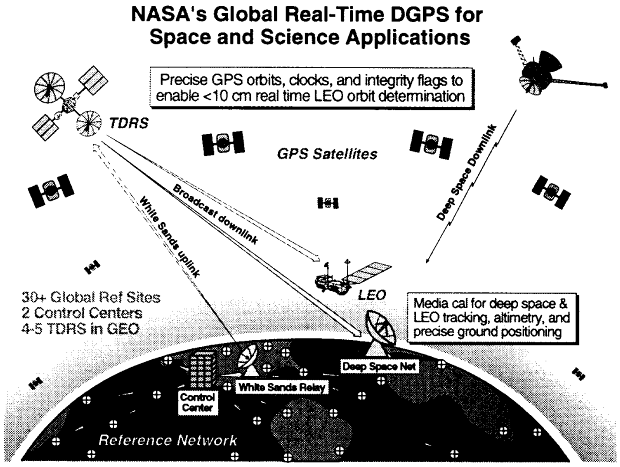

FIGURE 1. NASA GLOBAL WIDE AREA DIFFERENTIAL GPS SYSTEM.

where JPL's software would be running continuously. The software, consisting of RTG (Real-Time GIPSY) and WIS (Wide Area Ionosphere Software), processes the data in real time and provides real-time (latency of a second or so) knowledge of GPS orbits, GPS clocks (including a correction for the SA), and ionosphere delays over the entire globe. These corrections are uplinked to geostationary satellites, which could be NASA's TDRS, and then broadcast to the users. The users would receive these corrections within a second or two of real-time. JPL is also developing the special algorithms and software for user positioning and trajectory propagation using the wide area corrections, including correction for the effects of the second-level latency in the corrections. The goal of the NASA system would be to enable fully autonomous onboard satellite navigation, and thus save considerable resources in NASA ground systems for tracking and navigation. The initial goal would be to support real-time user positioning at the submeter level (adequate for all routine navigation and many precision applications), and improve in a later phase of development to better than 10 cm in real time (for precise science use).

(3) The FAA, after an exhaustive evaluation process in June 1996, chose JPL's pair of new real-time GPS software packages (RTG and WIS) for use in the Wide Area Augmentation System (WAAS), a system that will provide precision, GPS-based navigation to all airliners in U.S. airspace by late 1998. The FAA's WAAS (Fig. 2) is similar in some respects to the system shown in Figure 1. Some key differences are that the FAA system is, at least initially, a U.S. only system (versus NASA's global system), and that the FAA system has certain rigidly prescribed configuration, integrity, and performance requirements. In the long run, however, the FAA plans to become a key player in an international version of WAAS, as well.

With a NASA/Department of Transportation (DOT) interagency agreement and two software licenses signed off in late July 1996, JPL is now supporting WAAS and its implementation; a good example of technology transfer both to another agency, the Federal Aviation Administration (FAA), and to the private sector (Hughes is the prime contractor for the FAA WAAS). To provide these key and critical WAAS components, JPL is receiving funding that amounts to much less than 1 percent of the total $500M implementation cost for the FAA WAAS. Clearly, the U.S. government is getting a bargain by exploiting GPS tools and

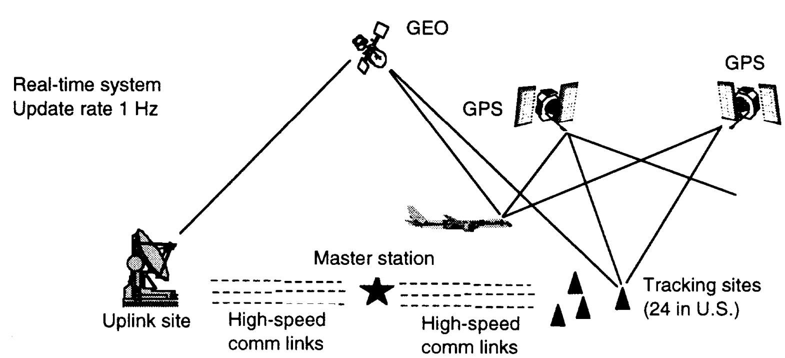

FIGURE 2. FAA WIDE AREA AUGMENTATION SYSTEM (WAAS) WILL USE JPL'S REAL-TIME SOFTWARE FOR ESTIMATION OF REAL-TIME WIDE AREA GPS CORRECTIONS.

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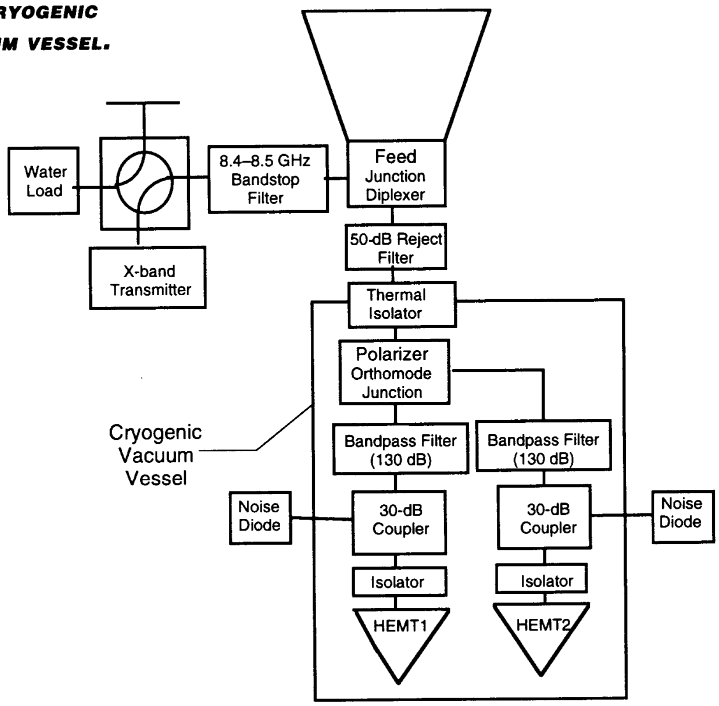
Figure 2. The new X-band feed junction system configuration; nearly all components that cause excess noise temperature are in the cryogenic vacuum vessel.

"Doubles" continued from page 2



bution is less because of the low physical temperature (15 Kelvin). The new feed junction diplexer technology has been successfully merged with the new LNA integrated, cooled, microwave components configuration designs for the front-end receivers.

What is the improvement in performance using this new feed junction diplexer? Table 1 shows both the original and new planned configuration system noise temperature predictions for the Goldstone 70-m antenna. The improvement in the system G/T on the 70-m antenna is astounding; the system noise temperature is reduced by nearly 3 dB. Comparing the columns of the noise temperature contributions, it is seen that the area of greatest improvement is the reduced waveguide losses with the feed junction diplexer. Figure 3 is a picture of the feedhorn, feed junction diplexer, and LNA as configured in preparation for a demonstration at DSS 13.

To meet the Cassini mission requirements, TMOD has selected the feed junction diplexer/HEMT LNA system for the DSN 70-m antenna X-band uplink task, as well as for upgrade of the five, 34-m BWG antenna network. The first 70-m antenna (Goldstone, DSS 14) and 34-m BWG antenna (Goldstone, DSS 25) will be completed in FY 2000, and the

Table 1. Noise temperature predictions of the Goldstone 70-m antenna X-band waveguide and feed junction diplexer configurations for uplink/downlink two-way mode.

Noise Temperature Components	Waveguide Diplexer Configuration (Kelvin)	Feed Junction Diplexer Configuration (Kelvin)
Cosmic Background	2.5	2.5
Atmosphere	2.26	2.26
Subtotal:		
Sky (accounting for atmospheric attenuation)	4.74	4.74
Antenna	5.0	3.8
Horn	1.0	1.0
Bethe Hole Coupler	0.3	0.3
Coupler Injected Noise	0.02	0.02
Ambient Load Switch	0.2	0.2
Feed Junction Diplexer and Filter	0	1.68
Waveguide Losses	15.48	0
LNA and Follow-up	4.0	4.5
Total, Predicted	30.2	16.2

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LEO-T DEVELOPMENT

TRACKING LOW-EARTH SATELLITES

NASSER GOLSHAN

Introduction

The Low Earth Orbit Terminal (LEO-T), is the prototype for a new class of low- cost ground stations life cycle cost of tracking National Aeronautics and Space Administration (NASA) missions in low- earth orbit. Development of the terminal was carried out in two phases by a small team of engineers at the Jet Propulsion Laboratory (JPL) and SeaSpace Inc., a satellite ground terminal manufacturer in San Diego, CA.

In the first phase, under a subcontract with JPL, SeaSpace upgraded a commercially available weather satellite-tracking terminal to receive telemetry data from NASA satellites. That first phase was completed in 1994 with successful demonstrations tracking two NASA science satellites—the Solar Anomalous and Magnetospheric Particle Explorer (SAMPEX), and the Extreme UltraViolet Explorer (EUVE), both operated by NASA's Goddard Space Flight Center, Greenbelt, MD. The telemetry demonstration was reported in *Telecommunications and Data Acquisition (TDA) Progress Report 42-125*.

In the second phase, command uplink capabilities were added to the prototype terminal by JPL. A week-long demonstration of the automated unattended uplink and telemetry operation of the LEO-Terminal with the COBE (COsmic Background Explorer) spacecraft was successfully completed at JPL on December 28, 1995. Analysis of the terminal logs and spacecraft telemetry indicated that the terminal worked flawlessly during the one-week demonstration. The combined telemetry/command capabilities of the LEO-T and its application are reported here.

Following the validation demonstration, the terminal has been left in unattended mode to track and receive telemetry data from low earth orbiting spacecraft with the objective of collecting long-term reliability statistics for the terminal. So far, the terminal has been in unattended operation for 26 months and logged a total of 3120 hours of tracking and telemetry reception from NOAA 12 and 14 weather satellites, SAMPEX, and COBE. Except for one system malfunction (burnout of a circuit board on the antenna controller subsystem on 5/21/96), the terminal has continued to work without any problem. The one failure in 26 months is consistent with the one- year Mean Time Between Failure (MTBF) design of LEO-Terminal.

LEO-T Characteristics

The prototype terminal is built entirely from commercially available subsystems. Use of Commercial Off-The-Shelf (COTS) equipment has enabled a rapid, low-cost development cycle and will ensure low recurring costs for future users. As shown in Figures 1 and 2, the prototype terminal consists of a 3-m aluminum mesh antenna enclosed in a fiberglass radome plus a 1.22-m (4-ft) rack that houses the station electronics.

The radome protects the microwave electronics and the antenna tracking

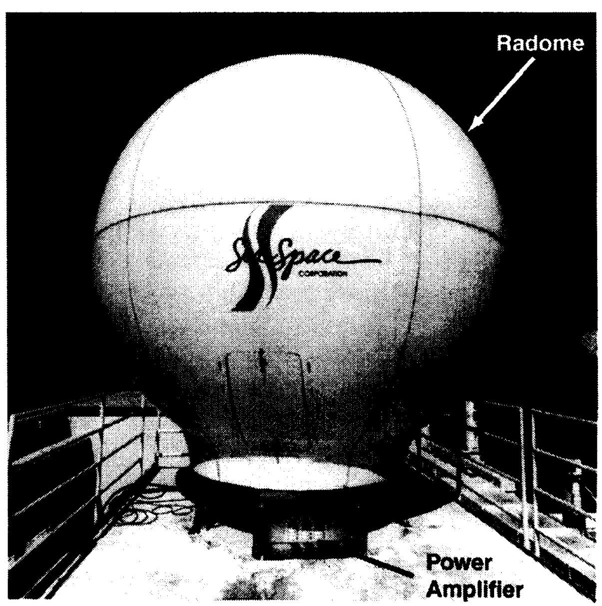

FIGURE 1. PHOTO SHOWS THE LEO-T RF SUBSYSTEM, ENCLOSED IN A RADOME ON ROOF OF BUILDING 238 AT JPL.

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